

CONTACT BEHAVIOR OF THE WHIRLIGIG BEETLE *DINEUTUS ASSIMILIS* (COLEOPTERA: GYRINIDAE)¹

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ABSTRACT: Touching interactions of individually sexed and numbered gyrid beetles (*Dineutus assimilis*) were observed and recorded in the laboratory. Certain individuals touched and were touched more than others. Males kept isolated from females were touched significantly more often immediately after being placed with females than they were when the sexes were allowed to cohabit for 48 hrs prior to testing. Significantly more touches occurred on the touched beetle's posterior third than on the middle or anterior thirds of the body. Because touching is non-random and related to daily activity patterns, a possible communication function is postulated.

Whirligig beetles (Coleoptera: Gyrinidae) swim on the surface of freshwater, eating material that falls on the water (Hatch 1925, Smith 1926, Balduf 1935). They are often numerous where they occur, aggregating together in large rafts (Heinrich and Vogt 1980).

Gyrinids usually swim circular paths. If disturbed, the beetles escape with a characteristic "dizzy whirling" but slower circles are the more usual means of locomotion. Kolmes (1983a) used the term "close circle" to describe close-range approaches to prey objects. Similar circles, however, frequently bring the beetles into proximity with each other and it is during these close encounters that they frequently touch one another. A touch consists of the "toucher" beetle bumping its head against the body of a "touchee." The forelegs may or may not be extended towards the "touchee" in the instant preceding contact. Typically, a beetle will touch another, swim several circles, and then return to touch that same individual again. This repetition of touching is seen despite the fact that all of the beetles may be moving in seemingly random circles of their own.

This study was undertaken to determine whether there were any predictable patterns to these physical touches; in particular whether certain body parts were touched more in these interactions, and whether different individuals either performed or received a disproportionate share of the contacts.

MATERIALS AND METHODS

Adult *Dineutus assimilis* Aubé were collected from a pond in Ithaca, NY during April and May 1980. The beetles were kept indoors (in a

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window) at room temperature (ca. 22°C) in plastic containers measuring 25 x 33 x 15 cm. Pond water was provided in the pans to a depth of 3-4 cm and was replaced every 2 days. A small mat of filamentous algae was added to each pan to provide resting/hiding places. To prevent escapes the trays were covered when not being observed.

Beetles were sexed immediately after collection and were maintained separately thereafter. Each beetle was tagged by applying white typing correction fluid to the elytra and scratching a number in the white spot with an insect pin. The marking was done in such a way that the beetles could fly and stridulate normally and both of these behaviors were observed during the experiment. Beetles were fed at least twice a week with live, disabled mosquitos (*Aedes aegypti*) from a university culture.

Beetles used in experiments were chosen at random from the single sex groups and placed together in a separate (identical) pan for data recording. Four trials used mixed-sex groups of 3 males and 3 females. Six single-sex trials used either 10 males or 10 females.

Two sorts of observations were made; in some trials the focal beetles were the "touchers" and in other trials the focal beetles were the "touchees." In head to head contacts it is moot which is "toucher" and which "touchee." In these cases, the "toucher" got the score if touchers were being watched and the "touchee" got the score if the touchees were being watched. Each beetle was watched for a predetermined number of touches, (either 10 or 15 depending on the trial), before moving on to the next individual in a randomized rotation.

Touch location and touch sequence were noted by recording a beetle's number followed by a second digit coded for contact location. Touches were divided into 3 categories (Fig. 1): #1 anterior, #2 middle, and #3 posterior, thirds of the body. A total of 1242 separate touching contacts were scored to determine which beetle touched which. Of those, 1099 were scored to determine the touch location on the beetle being touched.

Touches were not counted if they resulted from one or both beetles following the walls of the container. Touches were performed at varying speeds, however they were nearly always slow enough for the beetle numbers to be plainly visible. At times of great activity (e.g. if the pan was bumped accidentally) it is possible that some touches may have been too rapid to record.

RESULTS

Touch Location. Table 1 shows the results of 4 single sex trials while Table 2 shows the results of 2 mixed sex trials. The data from both indicate that a significantly greater number of touches occurred on the posterior third of the body. Therefore, the null hypothesis that touches were distributed equally among the 3 locations must be rejected (chi-square test, $p \leq 0.001$).

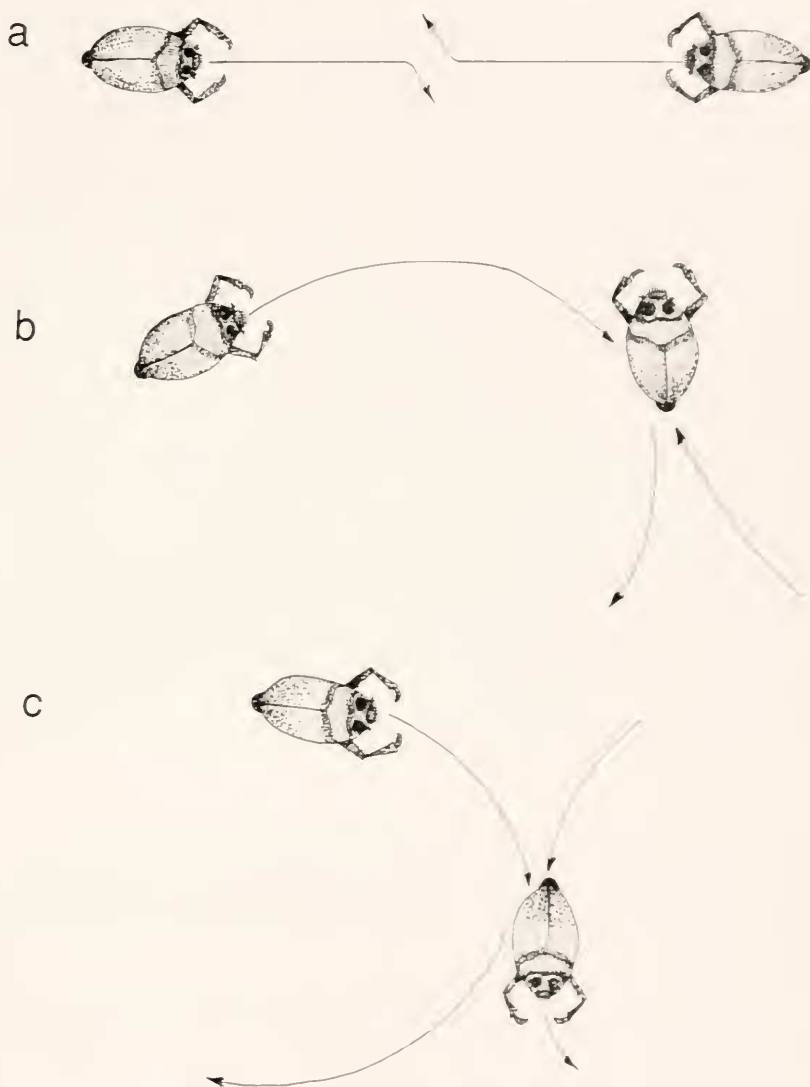


Figure 1. The 3 types of touch contacts made by *Dineutus* beetles while swimming on the water surface: (A) Type #1 contact, head to head. (B) Type #2 contact, touches on the middle third of the body, and (C) Type #3 contact, touches on the posterior third of the body. All contacts are made with the head of the touching beetle and are part of continuous circular or elliptical swimming. Note that types #2 and #3 could be made by the 'toucher' beetle approaching from either clockwise (illustrated) or counter-clockwise direction. In addition, the 'toucher' beetle could be on either side of the 'touchee.'

Touch Sequence. Touch sequences were recorded to see if beetles touched other available individuals randomly. Tables 3 and 4 show results of 4 trials in which 1242 contacts were scored in mixed sex interactions.

The first 3 trials, shown in Table 3, involved groups of 3 males and 3 females that had not contacted a member of the opposite sex for at least a week preceding the trial. The 799 contacts represented by these trials revealed that males touched males 192 times and females 195 times. Females touched males considerably more often than they touched other females, 268 times versus 144 times. The null hypothesis that the six individuals should receive equal number of touches is not supported (chi-square test, $p \leq 0.001$). In addition, these tests showed a significant sex difference; males were touched more by males and females than chance would allow (chi-square test, males touch males $p \leq 0.001$, females touch males $p \leq 0.05$).

An additional trial involving 443 contacts utilized beetles that were housed together for 48 hrs before the trial. These results, shown in Table 4, still indicated that touching was non-random (chi-square test, $p \leq 0.001$) but failed to reveal significant sex differences.

In all trials, certain individuals proved to be particularly active; touching and being touched more often than others. If the data in Tables 3 or 4 are used to form dyads (paired sums of all contacts between, for example, male Aa and female Bb plus all contacts of female Bb with male Aa), these clearly indicate that some beetles were the centers of more contact than others. Yet these individuals were not perceptibly different (e.g. larger or more centrally located in the group) than the others.

Table 1. Combined results of 4 single sex trials showing touch location. All trials involved 10 beetles of the same sex; 2 trials with males, 2 with females. Each trial involved watching a focal individual make 10-15 contacts, then selecting another focal individual until all had been observed.

Touch Location*	Trial Number and Composition				Total Touches
	1 Males (n=10)	2	3 Females (n=10)	4	
Anterior	50	36	43	24	153
Middle	39	44	37	48	168
Posterior	61	55	68	48	232

*See Fig. 1

Table 2. Combined results of 2 mixed sex trials showing touch location. The specific individuals touched are indicated with the location where they received touches.

Touch Location*	Number of Touches Received by Focal Individuals						Total
	1	2	3	4	6	9	
	Females			Males			
Anterior	25	13	11	30	18	27	124
Middle	24	21	11	33	29	42	160
Posterior	40	26	48	42	52	54	262

*See Fig. 1

Table 3. Matrix of the combined results of 3 trials in which the individuals touched are scored according to which individuals touched them irrespective of touch location. Sexes were maintained separately until just before trials.

Individual Performed Touching	Number of Touches Received by Individuals						
	Females				Males		
		1	2	3	4	6	9
Females	1	—	17	19	34	25	42
	2	31	—	26	28	27	25
	3	27	24	—	29	28	30
Males	4	29	18	17	—	34	39
	6	19	17	11	36	—	29
	9	38	27	19	27	27	—

Table 4. Matrix of the results of a single trial of 432 contacts. Individuals touched are scored according to which individuals touched them irrespective of touch location. Sexes were housed together for 24 hrs prior to the trial.

Individual that Performed Touching	Number of Touches Received by Individuals						
	Females				Males		
		4	6	10	2	9	5
Females	4	—	12	12	5	29	19
	6	11	—	20	8	21	12
	10	13	23	—	16	12	8
Males	2	8	18	19	—	20	12
	9	8	29	16	10	—	10
	5	18	16	5	10	23	—

DISCUSSION

Gyrinids are extremely precise and agile in their movements. Consequently, it seems unlikely that their bumps should be accidental or without function. Moreover, the same frequent inter-individual contacts may be seen in rafts of wild whirligigs unconstrained by laboratory container or enforced crowding. Several authors have mentioned gyrinids touching or bumping into one another as incidental to some other behavior (e.g. Kolmes 1983b; Hatch 1925). Bendele (1986) details the "chasing behaviour" of 2 *Gyrinus* species but only mentions that "a beetle pursues another one and occasionally catches it." I conclude that patterned touching behavior in whirligigs has not been previously reported. It is apparent in all *Dineutus* species I have observed.

Touch sequence data did not demonstrate consistent sex differences but did show that touching is non-random. Sexual behavior was not observed either in the laboratory or in the field during the period of this study. My own observations and notes by Smith (1926) indicate that mating and oviposition occur later (in late May and June) in the Ithaca area, so it may have been too early to detect sexual behaviors. Differences between Tables 3 and 4 thus might be due to novelty effect rather than sex.

Recent attention has been focused on potential benefits of aggregation in neustonic insects (Brönmark *et al.* 1984; Deshefy 1980; Foster and Treherne 1981; Treherne and Foster 1981, 1982). Heinrich and Vogt (1980) studied both the adaptive benefits of rafting and also the temporal mechanisms of raft construction. I have (personal observation) noted strongly patterned diel cycles in whirligigs where touching frequency was correlated with other daily activity levels.

The decided preference for posterior touching may be related to the presence of exocrine glands in this area (Hatch 1927; Newhart and Mumma 1979). The defensive function of these glands has received most attention (Meinwald *et al.* 1972; Benfield 1972), but the possibility of intraspecific chemical communication has not been eliminated. Since the beetles touch with their head (and thus antennae and mouthparts) it is at least possible that some chemical cues are being detected.

Based on these results, I propose that *Dineutus* individuals use physical contacts to mediate their rafting behavior. This mechanism would be a simple yet effective way of transferring information. Further study will be needed to test how touching corresponds to overall activity levels and whether this behavior is used in some self-assessment by beetles in a raft.

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